THE EXTINCT BISONS OF NORTH AMERICA; WITH DESCRIPTION OF ONE NEW SPECIES, BISON REGIUS.

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Since Frederic A. Lucas [1] wrote, in 1899, his paper on The Fossil Bisons of North America, a considerable number of new specimens have found their way into the various collections; and some of these furnish more complete portions of the skull than were known at that time. It seems therefore proper that these new acquisitions should be described and illustrated; and this the writer proposes to do, having, through the courtesy of the officers of the United States National Museum, the American Museum of Natural History, the Field Museum of Natural History, Earlham College, Indiana, and the University of Kansas, had free access to the materials in their possession.

Inasmuch as many European writers have been disposed to refer the fossil bisons of North America, except perhaps *B. latifrons*, to the European species, *Bison priscus*, it seems to be necessary to consider that name and the forms which have been arranged under it.

Anyone who examines the various figures of skulls to which this name has been applied must be struck by the great differences which are presented by them in the length of the horn-cores, their direction, and the amount of their curvature. As examples of these may be taken two skulls figured by H. v. Meyer.[2] Figure 1, plate 8, represents the former, found near Pavia, Italy. Figure 2 of same plate shows the latter, supposed to have been brought from Hungary. Another example is represented by figures 1, 2 of plate 15, a specimen found in Siberia, in the case of which the horn-sheaths are yet present. Figure 3 of plate 8 is reproduced from the skull described by Pallas,[3] and found on one of the tributaries of the Yenesei River, in Siberia. As will be observed the horn-sheaths had been preserved. Tscherski[4] described this skull, comparing it with a number of others.

[1] Proc. U. S. Nat. Mus., vol. 21, pp. 755–771, pls. 65–84.
[2] Nova Acta, etc., vol. 17, 1835, pls. 10, 11.
[3] Nova Comment. Acad. Petropol., vol. 13, 1769, p. 462, pl. 11, fig. 1.
[4] Mém. Acad. Imp. Sci. St. Petersb., ser. 7, vol. 40, 1893, p. 76.

The attitude assumed by most European writers, especially the older ones, on the relationships of the fossil bisons of the northern parts of the eastern and the western hemispheres is well illustrated by the language of J. F. Brandt.[1] This author, having studied the rich materials in the St. Petersburg Academy, expressed himself unhesitatingly as regarding *Bison priscus* Bojanus and *Bos latifrons* Fischer as identical with *Bison bonasus* of Europe. He further affirmed that, notwithstanding the contradiction which he had to expect in America, he identified *Bison latifrons* (Harlan) and *Bison antiquus* Leidy, together with *Bos priscus* Bojanus, as mere races of one primitive form.

It is very probable that to-day few naturalists would deny that all these forms have descended from a common and not far removed ancestor. There is, however, in our time, hardly one who will affirm that the European bison is the same species as the North American animal; and there are few who will contend that our *Bison latifrons*, with its immense horns, was specifically identical with the short-horned *Bison bonasus* of Europe, or even with the forms that have been included under the name *Bison priscus*.

It is only recently that an effort has been made to establish distinct species and subspecies on the materials which have been found from the British Isles to Eastern Siberia in Pleistocene deposits. In 1909[2] La Baume, in an interesting paper on fossil and subfossil oxen of the Old World, discussed ten skulls of *Bison priscus*, and presented numerous measurements. Some of these skulls he figured. They had been collected in as nearly as many localities, scattered from the Rhine to eastern Siberia. He concluded that, as regards the measurements of the skulls themselves, there appeared to exist no great differences, but he appreciated the fact that there existed very great differences among the horn-cores of the different skulls which had been described by the various European writers. On pages 52–54 he gives a brief history of the several attempts which had been made to explain these differences; and he shows in a striking way the difficult position in which these writers had placed themselves in their resolution to regard all these forms of bisons as belonging to a single species. La Baume expresses this conclusion: "It is impossible to refer to geographical varieties all the variations in the form of the horn-cores of *Bison priscus;* since very different sorts of horn-cores are found within very narrowly restricted regions and, on the other hand, horn-cores from widely removed localities agree completely." The writer quoted did not attempt to establish any new species, regarding it as necessary to await the accumulation of additional and better materials.

[1] Verh. russ. mineral. Ges., ser. 2, vol. 2, pp. 137, 150.

[2] Schriften naturf. Ges. Danzig, n. s., vol. 12, Heft. 3, pp. 45–80.

It may be here remarked that La Baume, following Nathusius, made use, as a standard for comparison, of a measurement which is to be recommended; but which the present writer has not been able to use to any considerable extent. This measurement is the distance from the lower border of the foramen magnum to the base of the nasals. In but few fossil skulls can the basilar length be obtained; while in many the fronto-nasal suture remains. The measurement in question, called by La Baume "Schädeldurchmesser" might be called in English the basinasal length.

In the same year that La Baume published his paper Max Hilzheimer[1] described as a new species *Bison primitivus*. The type of this species had been found near Kisensk, on the Lena River, Siberia. This will be referred to again on page 177. In a second paper[2] Hilzheimer described *Bison uriformis*, basing it on part of a skull with complete horn-cores, found near Kottbus, in Prussia; also, *Bison europæus lenensis*,[3] on a nearly complete skull, with horn-sheaths, which had been collected on the Vilui River, an affluent of the Lena; furthermore, he recognized[4] a second specimen of his *B. primitivus*, brought from Vologda, in Eastern Russia. The two last-named skulls were among those studied by La Baume.

If the fossil bisons of Europe are to be subdivided into species, or, as some doubtless prefer to call them, subspecies or races, it will be first of all necessary to determine what is the form to which the term *priscus* is to be applied. This may not be a wholly easy matter; at least, so far as the writer knows, no one has yet attempted to place the name on a solid basis. It is generally credited to Bojanus[5] who uses the combination *Urus priscus*. If this were the first use of the specific name, as applied to a fossil bison, the reviser might select as the type any one of the five specimens catalogued by Bojanus; and thus the further usefulness of the name would depend on the quality of the reviser's mercy. However, Bojanus himself indicates ("nomine aliis auctoribus iam recepto") that he was not the first to use the name. H. von Meyer's Palæologica, etc., in which he states that he has dealt with the literature, is not accessible to the present writer; but he finds, through the good offices of Dr. C. W. Richmond, that Schlotheim, in 1820,[6] applied the title *Bos urus priscus* to three specimens which had been found somewhere in the neighborhood of Gotha, Germany. One of these was a complete horn-core, over 2 feet long; another, the lower half of a still thicker horn-core, together with a part of a skull. Schlotheim

[1] Jahreshefte Ver. vaterl. Naturk., Württemberg, 1909, pp. 241–269, pls. 6, 7.
[2] Sitz.-Ber. Ges. naturf. Freunde, Berlin, 1910, p. 138, figs. 3, 4.
[3] Page 144, figs. 8, 9.
[4] Page 142, figs. 6, 7.
[5] Nova Acta, etc., vol. 13, 1827, p. 427.
[6] Petrefactenkunde, p. 10.

stated that his specimens agreed wholly with figures which had been published by Faujas, of a skull which had been found in the Rhine near Bonn. The horn-cores of this skull had, however, lost their extremities. H. Bronn, author of the article on "Ochsen",[1] makes this disposition of Schlotheim's name: "1, *Bos taurus* Lin. var. *fossilis* Cuv. (*Bos urus priscus*, v. Schloth.)," J. F. Brandt[2] seems to refer Schlotheim's name to *Bos primigenius*. It seems probable, however, that the complete horn-core in Schlotheim's hands resembled those here figured, after v. Meyer (pl. 8, figs. 1, 2), or those of the skull represented by Owen.[3] It is very probable that the specimens mentioned by Schlotheim are yet in existence; and if so, and if Schlotheim's use of the name *priscus* for a fossil bison of Europe is the earliest, one of the three specimens, preferably the most complete one, ought to be selected as the type of *Bison priscus*, and it ought, further, to be carefully figured and described. We would then have for our building a fixed corner stone, even though it might not be one that furnishes everything that could be desired.

The first of the American species of extinct bison to be considered is *Bison antiquus* Leidy.

BISON ANTIQUUS Leidy.

It is unfortunate that the types of so many species of fossil animals are very imperfect specimens. That of *Bison antiquus* consists of only a portion of the right side of the skull bearing a part of the horn-core. This fragment has likewise been eroded somewhat, so that the exact dimensions and form can not be determined. This results in somewhat different estimates.[4] The writer has attempted here to restore in outline the missing part of the horn-core, so that one may form a judgment regarding its shape (fig. 1). At a later time Leidy referred to the same species a skull lacking all in front of the orbits, but with complete horn-cores, which had been discovered in California. This was figured by Leidy under the name *Bison latifrons*.[5] Rhoads[6] made this specimen the type of *Bison californicus*. The writer[7] described and illustrated, under the name *B. antiquus*, a skull which is in Earlham College, Richmond, Indiana, and which was discovered some years ago near Vincennes, Indiana. The figures are here reprinted (figs. 2, 3). This skull differs from

[1] Ersch und Gruber's Encyclopädie der Wissenschaften und Künste, sec. 3, 1836, p. 278.

[2] Verh. russ. mineral. Ges., ser. 2, vol. 2, p. 186.

[3] Brit. Foss. Mammals and Birds, p. 491.

[4] Allen, American Bisons, p. 26; Lucas, Proc. U. S. Nat. Mus., vol. 21, 1899, p. 760; Hay, Geol. Surv. Indiana, vol. 35, 1912, p. 650.

[5] Extinct Vert. Fauna, pl. 28, figs. 4, 5; Lucas, work previously cited, pls. 69, 70.

[6] Proc. Acad. Nat. Sci. Phila., 1897, p. 501.

[7] Work previously cited, p. 650. figs. 50, 51.

that found in California in having slenderer horns. This may be explained on the supposition of a difference of sex. There seem to be some differences in the proportions of the cranium likewise. In the Indiana specimen the distance from the occiput to a line joining the hinder borders of the orbits is about 73 per cent of the width at the rear of the orbits; in the California specimen the corresponding estimate is about 69 per cent. However, in four skulls of the American bison a range is found which is equally great. It seems to the writer that we must believe that the California specimen and that found in Indiana belong to the same species. The characters that distinguish this bison are found, as pointed out by Lucas, in the horns, which are about as long as the skull is wide, rapidly tapering, somewhat sagging, at the base, recurved at the tip, and directed outward in a plane at right angles with the midline of the skull. In all

FIG. 1.—BISON ANTIQUUS. TYPE. PART OF SKULL. HORN-CORE RESTORED TO SHOW FORM.

the other species of North American and apparently also of European bisons the axis of the base of the horn-core is directed more or less toward the orbit of the opposite side.

In his work The American Bisons, Living and Extinct, page 21, published in 1876, J. A. Allen accepted this species as being distinct from the European *Bison priscus;* but, he included in it *Bison crassicornis,* of Alaska; as well as remains which have since been recognized by Lucas as *B. occidentalis.* He was therefore entirely consistent when he gave his judgment as follows:

> The types here recognized as distinct forms under the names *B. priscus* and *B. antiquus,* it should be remarked, differ but slightly from each other—not more so, probably, than do *B. bonasus* and *B. americanus,* if indeed so much—and constitute, as it were, a common circumpolar form from which *B. bonasus* and *B. americanus* have probably been differentiated.

Richard Lydekker, in his Wild Oxen, Sheep, and Goats, etc., published in 1898, on page 61, regarded *B. antiquus* and *B. crassicornis*

(as well as materials now called *B. occidentalis*) as synonyms of *B. priscus*, the extinct bison of Europe. He figured a skull, lacking the part in front of the orbits and bearing the horn-cores, which had been found at Ilford, Essex, England. There is a cast of this in the United States National Museum, and from this photographs have been made and reproduced (pl. 9, figs. 1, 2) for comparison with the

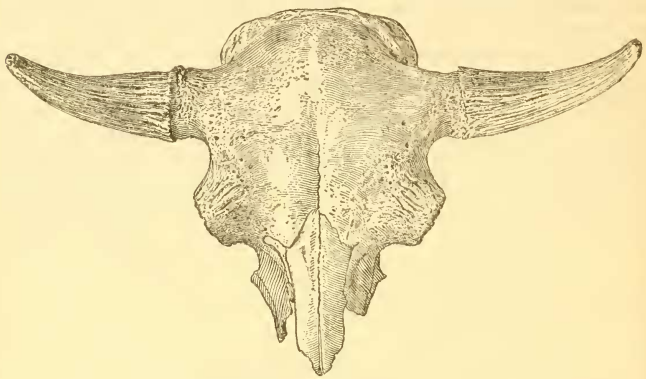

FIG. 2.—BISON ANTIQUUS. SKULL AT EARLHAM COLLEGE. FRONTAL VIEW.

figures here given of other species of extinct bisons. Mr. Lydekker regards this skull as that of a very large bull.[1] It appears to be the same specimen that Richard Owen [2] thought might be the skull of a female. Attention may likewise be called to another specimen which was dug up at Woolwich, England, and of which Owen published a figure on page 49 of the work just cited. The horn-cores have

FIG. 3.—BISON ANTIQUUS. SKULL AT EARLHAM COLLEGE. VIEW FROM THE REAR.

an appearance quite different from that of the specimen found at Ilford, being much slenderer and apparently not so much curved. From the cast of the Ilford specimen the present writer has obtained the following results. For comparison the corresponding measurements are taken from the specimen of *B. antiquus* which is at Earlham College and of the California skull which has been called by Rhoads *B. californicus*.

[1] Cat. Foss. Mamm., pt. 2., p. 24.
[2] Brit. Foss. Mammals and Birds, p. 494.

Measurements of skulls.

Dimensions taken.	*B. priscus*, No. 45392, B. M.	*B. antiquus*, Earlham College.	*B. californicus.*
	mm.	*mm.*	*mm.*
Width between bases of horn-cores	340	400	400
Width at the rear of the temporal fossæ	233	205	.....
Width across mastoids	330	310	360
Width at rear of orbits	395	360	.....
Width between orbits and horn-cores	340	310	360
Length from occipital crest to line joining the rear of the orbits	283	263	.....
Distance from lower border of foramen magnum to rear of nasals, basinasal length	308	292	.....
Length along upper curve of horn-core	520	290	290
Length along the lower curve of horn-core	610	355	326
Distance between tips of horn-cores	1,020	880	880
From outside to outside of horn-cores, greatest	1,120	880	880
Greatest diameter of base of horn-core	138	103	115
Least diameter of base of horn-core	115	90	110

It ought to be stated here that the measurements of the specimen of *B. priscus* which were recorded by Mr. Lydekker in the catalogue, as cited, differ from the corresponding ones here given, not having been taken in the same way, the length of the horn-core, 375 mm., being taken evidently in a straight line. It is further to be noted that in the present paper the distance between the bases of the horn-cores is taken across the forehead where the rough bases approach each other most nearly. Some authors appear to take the measurement between other points.

The skull from California which has been regarded as *B. antiquus* has horn-cores of nearly the same length as those of the Earlham specimen, but they are of greater diameter at the base. We may therefore regard the California skull as being that of a bull; the other, that of a cow. Is it then possible that the English skull with a narrower forehead, greater width at the orbits, and immensely longer horns, besides other differences, belonged to a bull of the same species? The writer does not think so.

BISON OCCIDENTALIS Lucas.

The type of this species is in the United States National Museum and has the catalogue number 4157. It was discovered by Sir John Richardson, at Fort Yukon, Alaska, where the Porcupine River empties into the Yukon. The specimen consists of the rear of the skull bearing the two horn-cores. Of the left horn-core the distal extremity is missing. Inasmuch as a number of other specimens which are to be referred to the same species have come to light, it seems best to consider them. Figures are here presented of the type skull (pl. 9, figs. 3, 4).

The most nearly complete skull of this species known to the writer is one in the American Museum of Natural History. Through the liberality of the officers of the museum the writer has been furnished with photographs of this skull, and from these the figures here shown

have been prepared (pl. 10, figs. 1, 2, 3, *a*). The skull was found in the Fox Gulch mine, near Dawson, Yukon Territory, and was presented to the American Museum of Natural History by George T. Coffey, through L. S. Quackenbush. The catalogue number of the specimen is 13721. This skull lacks the lower jaws; likewise the maxillary, the premaxillary, and the lachrymal of the right side are missing. The true molars of the left side are present, but are somewhat shattered and consequently have not been figured. The measurements taken are found in the second column of the following table. In the first column are the corresponding measurements from the type-specimen, so far as they can be obtained:

Measurements of skulls.

Dimensions taken.	Type.	13721 A.M.N.H.	5514 U.S.N.M.	2643 U.S.N.M.	Univ. Kansas.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*
Length from the rear of the occipital condyles to front of premaxillæ	.....	573	.....	.....	600
Length from front of foramen magnum to front of premaxillæ	.....	537	.....	.....	560
Length from middle of occipital crest to front of premaxillæ	.....	600	.....	.....	615
Length from middle of occipital crest to front of nasals	.....	465	.....	.....	533
Length from middle of occipital crest to rear of nasals	266	285	280	260	271
Distance from upper lip of foramen magnum to middle of occipital crest	107	110	102	102	.....
Distance between bases of horn-cores	297	335	320	312	370
Distance from lower border of foramen magnum to rear of nasals, basinasal length	280	.....	270	.....	.....
Width of skull at the auditory openings	273	280	290	298	305
Width of skull at the hinder ends of the temporal fossæ	175	200	187	202	195
Width of skull at constriction between orbits and bases of horn-cores	297	295	298	300	360
Width of skull at the rear of the orbits	355	355	368	.....	397
Width of skull at the maxillo-malar sutures	.....	235	.....	.....	.....
Width of muzzle at middle of length of premaxillæ	.....	143±	.....	.....	.....
Width of palate between anterior premolars	.....	90	.....	.....	.....
Width of palate between hinder molars	.....	132	.....	.....	.....
Width across nasal bones, in straight line	.....	97	.....	.....	.....
Diameter of orbit	.....	72	.....	.....	.....
Diameter of base of horn-cores, fore-and-aft	102	118	105	115	107
Diameter of base of horn-cores, vertical	96	95	88	95	92
Circumference of horn-cores at base	300	320	310	336	325
Length of horn-cores on upper curve	298	355	330	352	310
Length of horn-cores on lower curve	365	420	415	415	375
Distance between tips of horn-cores	700	920	810	808	880
From middle of occipital crest to rear of orbit—straight line	290	288	295	.....	.....

The following are the measurements of the molar teeth; and in the second column the corresponding measurements of the molars of two American bisons, the stage of wear being about the same:

Measurements of teeth.

Teeth measured.	13721 A.M.N.H.	22638, U.S.N.M.	22374, U.S.N.M.
	mm.	*mm.*	*mm.*
Length of the molar series	92	92	93
$M.^1$ length	25.5	26	26
$M.^1$ width	26	25	26.5
$M.^2$ length	31	33	33
$M.^2$ width	29	25	28.5
$M.^3$ length	33	33	34
$M.^3$ width	29	23	28

It will be observed that there is no considerable differences in the measurements of the teeth of the two species; and, had we more individuals, these differences might disappear. However, a difference is seen in the structure of the last molars of the two species. On the anterior half of the outer face there are, in *B. occidentalis*, three pillars which descend from the base of the tooth, instead of two, as in the existing bison. That is, the deep valley or groove just opposite the posterior horn of the anterior crescent of *Bison bison* is, in *B. occidentalis*, occupied by a pillar about equal in diameter to the pillar just behind it and belonging to the hinder half of the outer face of the tooth. This extra pillar is not present in the other two molars.

It will be seen that in various ways this specimen differs from the type. The skull has exactly the same width, 355 mm., at the rear of the orbits, and the cranial length (from the middle of occiput to line joining the rear of the orbits) is practically the same. Nevertheless, the distance between the bases of the horn-cores is greater by 38 mm.; the distance between the hinder ends of the temporal fossæ is 25 mm. greater; the circumference of the base of the horn-cores is somewhat greater; the horn-cores are longer by about 55 mm. and the distance between the tips of the horn-cores is greater by 220 mm., the latter greater dimension being partly due to the less abrupt curvature of the horn-cores. When the figures showing the rear of the skulls is examined (pl. 9, fig. 4; pl. 10, fig. 2) it is seen that the forehead of the American Museum specimen is more swollen than that of the type and that the horn-cores sag somewhat more than in the type. It may be observed that similar differences exist in the American bison and that the sagging of the horns seems to be associated with the inflation of the forehead.

In both the type and in the American Museum specimen the axis of the horn-cores is directed pretty nearly toward the orbit of the opposite side. Also in both a line joining the extremities of the horn-cores passes somewhat behind the occiput; slightly less in the type than in the other specimen.

It is proposed next to describe the skull and briefly the skeleton of a specimen which is in the University of Kansas and which is assigned to *B. occidentalis*. This was found near Russell Springs, Logan County, Kansas, and was described originally by Alban Stewart, under the name *Bison antiquus;* later by Lucas and McClung, who referred it to *Bison occidentalis*. Both Stewart and McClung gave numerous measurements. The specimen has been mentioned also by Williston in two or three papers. With this bison were found six or seven other individuals, all probably members of one herd. Beneath the scapula of this fine individual H. T. Martin

found a flint arrowhead. This fact has been treated by Williston and McClung.

Besides the measurements of the skull (figs. 4 and 5) presented on page 168, in the fifth column, it may be added that the width at the rough eminence above the fourth premolar is 168 mm.; the lower jaw has a height of 72 mm. at the hinder molar.

The teeth are worn down well toward the roots. The upper tooth line, not including the missing pm.^{2}, is 144 mm. long. The following are the dimensions of the teeth so far as obtainable:

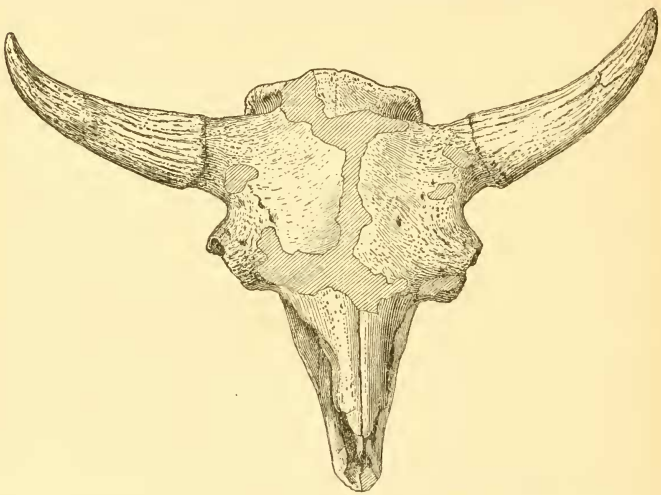

FIG. 4.—BISON OCCIDENTALIS. SKULL AT KANSAS UNIVERSITY. FRONTAL VIEW.

Measurements of teeth.

Upper.		Lower.	
	mm.		*mm.*
M.^{1} length	24	Pm.$_2$ length	14
M.^{1} width	30	Pm.$_2$ width	10
M.^{2} length	29	Pm.$_3$ length	20
M.^{2} width	29	Pm.$_3$ width	11.5
M.^{3} length	33	M.$_3$ length	54
M.^{3} width	25	M.$_3$ width	30

The width of m.^{3} was taken across the hinder lobe, the front lobe being injured; the widths of pm.$_2$ and of pm.$_3$ were taken at the rear. M.$_3$ measured across the middle lobe 29 mm.; across the hinder lobe, 11 mm. Inasmuch as the length of each tooth diminishes as it is worn toward the base, the lengths were doubtless greater earlier in life. For the dimensions of the upper teeth in skulls of *Bison bison*

at hand, see table on page 168. In the lower jaw of another *Bison bison*, No. 172689, U.S.N.M., from northern Alberta, the length of the last lower molar is 46 mm.; the width across the front lobe, 21 mm.; across the middle lobe, 20 mm.; across the hinder, 11 mm. It will be seen that at least this tooth in the fossil species is longer and especially much wider than in the existing bison. The dimensions of the upper teeth of this Kansas specimen differ somewhat from those of the specimen in the American Museum of Natural History.

As regards the direction taken by the horn-cores it may be said that a straight line joining the tips has its middle point 90 mm. above the occipital crest and at a somewhat shorter distance behind it. Near the bases the horn-cores are directed outward, somewhat back-

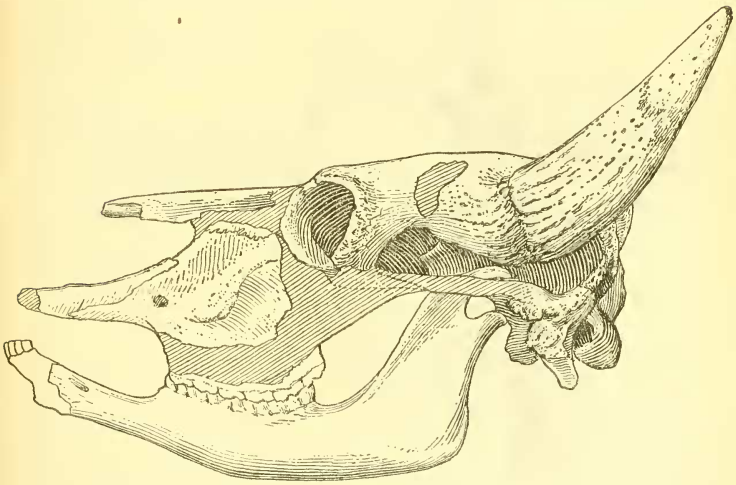

FIG. 5.—BISON OCCIDENTALIS. SKULL AT KANSAS UNIVERSITY. LATERAL VIEW.

ward, and slightly downward, but soon beginning to rise. At the base the horn-cores are only slightly flattened.

Measurements of the other parts of the skeleton have been published by Stewart and McClung. A drawing of the whole skeleton is here presented (fig. 6), prepared from a photograph furnished by the University of Kansas. The atlas is wholly artificial. The centrum of the axis has a length of 110 mm.; its spine rises 170 mm. above the lower surface of the centrum. The spine of the seventh cervical is 510 mm. high, but it is partly restored. The spine of the first dorsal is 540 mm. high; of the second, 600 mm. high. The centrum of the fifth dorsal is 72 mm. long; that of the tenth dorsal, 61 mm. long; that of the first lumbar, 70 mm. long. The sacrum has a length of

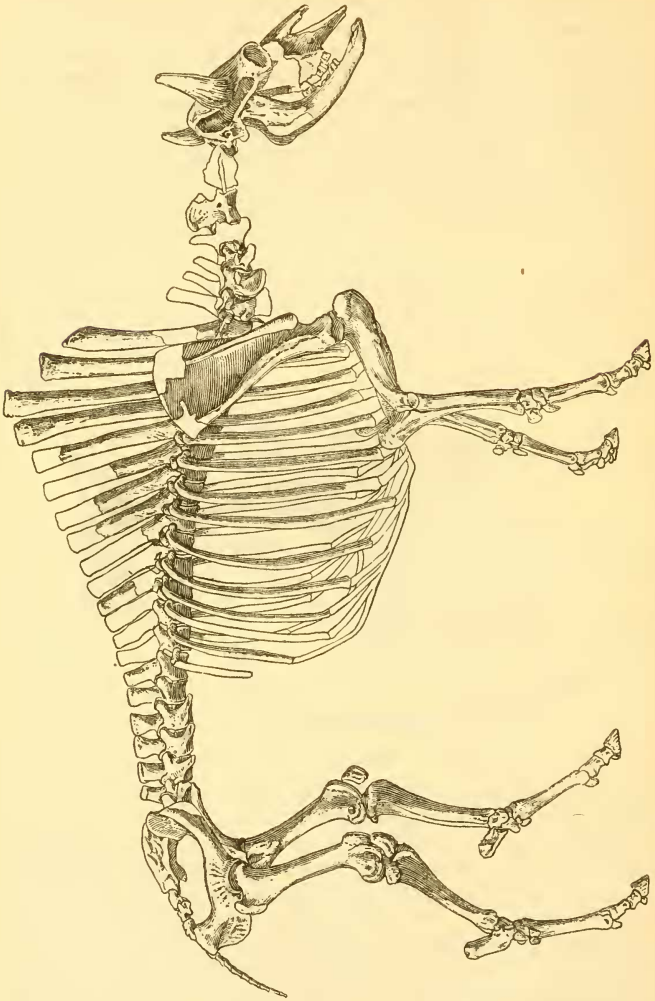

FIG. 6.—BISON OCCIDENTALIS. SKELETON AT KANSAS UNIVERSITY.

280 mm. The following additional measurements are given, and for comparison the corresponding ones of a mounted American bison in the U. S. National Museum, No. 12456.

Measurements of the scapula, pelvis, and limb bones.

Dimensions taken.	*Bison occidentalis.*	*B. bison.*
	mm.	*mm.*
Scapula:		
Length	575	490
Width of upper end	300	300
Humerus:		
Total length	396	315
Length from head to distal end, inner side	365	305
Fore-and-aft diameter of middle of shaft	65	72
Width of articular surface at lower end	107	110
Ulna, total length, in a straight line	470	435
Radius:		
Total length	345	335
Transverse diameter of middle of shaft	58	57
Transverse diameter of lower end	102	93
Anterior cannon bone:		
Length	210	206
Transverse diameter at lower end	88	82
Pelvis:		
From anterior end to middle of acetabulum	330±	295
From middle of acetabulum to rear of ischium	282±	280
Distance from lower border of one acetabulum to that of the other	220	212
Femur:		
Total length	523	440
Length from head to lower border of inner condyle	487	400
Transverse diameter at middle of shaft	60	53
Distance from inner surface of head to outer surface of greater trochanter	175	160
Tibia:		
Total length	436	412
Width of lower end	87	82
Calcaneum, total length	170	162
Hinder cannon bone:		
Total length	260	255
Transverse diameter at middle of length	40	40

It will be seen that, as compared with the mounted American bison, the Kansas specimen has all the limb bones longer, but not greatly longer. The length of the hind leg from the femur down, in the Kansas specimen, is 930 mm.; in the mounted American bison, 860 mm. Most of the measurements of the skull indicate a somewhat larger animal than the specimen in the American Museum of Natural History, No. 13731. The horn-cores are, however, considerably shorter than in the latter specimen. One of the most remarkable features of this specimen is the narrowness of that part of the face in front of the orbits. In this respect it is wholly different from the American Museum specimen and from one figured by Quackenbush [1] here reproduced (pl. 10, fig. 3, *c*), and from all other known specimens from Alaska or elsewhere. One might readily suppose that such a difference would indicate a distinct species. However, in Lydekker's Wild Oxen, Sheep, and Goats, there is a view of the skull of a bull and one of a cow of the European bison; and in the bull the face is narrowed as it is in the Kansas specimen. For the present, therefore, it seems best not to remove this specimen from *B. occidentalis*.

[1] Bull. Amer. Mus. Nat. Hist., vol. 26, pl. 17.

In the United States National Museum are two specimens which the writer refers to this species. They have the catalogue numbers 5514 and 2643. Each consists of the hinder part of the skull, together with the horn-cores.

No. 5514 (pl. 11, figs. 1, 2) was found on the Tanana River, about 20 miles above its mouth, by Mr. Charles Sheldon, by whom it was presented to the United States National Museum through Mr. W. H. Osgood. The measurements are to be found in the third column on page 168.

No. 2643 of the United States National Museum (pl. 11, figs. 3, 4) was obtained on the Old Crow River, in Yukon Territory, by A. G. Maddren, of the United States Geological Survey. It consists of the rear of the skull bearing the complete horn-cores. A figure showing the skull and horn-cores from behind was published by Mr. C. W. Gilmore.[1] The measurements are presented in the fourth column on page 168. The horn-cores are more strongly grooved than in most specimens. Both of the specimens just mentioned have likewise the horn-cores more flattened than most other individuals.

In the Field Museum of Natural History, Chicago, there is part of a skull with both horn-cores, the one of the right side lacking the tip (pl. 12, figs. 1, 2). The cranium is preserved to the fronto-nasal suture. The specimen is labeled as having come from Point Barrow and was purchased in 1902 from the University of Pennsylvania. The figures show the directions taken by the horns. The forehead is nearly flat.

The following measurements were taken by the writer:

Measurements of No. 6832, Field Museum Natural History.

	mm.
Width at the rear of the orbits	330
Width between the orbits and bases of horn-cores	290
Width between bases of the horn-cores	310
Extent from tip to tip of horn-cores (estimated)	860
Distance between the hinder ends of the temporal fossæ	193

In the American Museum of Natural History there is part of a skull (pl. 12, figs. 3, 4) which presents the face as far forward as the fronto-nasal suture and both horn-cores, of which the left one is imperfect and the right one lacks a small part. The exact locality is unknown, but it is said to have been found somewhere in the valley of the Ohio River. This skull has furnished the following measurements:

[1] Smiths. Misc. Coll., vol. 51, pl. 12.

Measurements of skull in American Museum Natural History.

	mm.
Distance from middle of occipital crest to fronto-nasal suture	266
Distance between bases of horn-cores	290
Width of constriction between orbits and bases of horn-cores	277
Width at the rear of the orbits	325
Distance between hinder ends of temporal fossæ	170
Width at ear-openings	300
Height of occipital crest above lower lip of foramen magnum	150
Height of occipital crest above upper lip of foramen magnum	110
Length of horn-core on upper curve	325±
Length of horn-core on lower curve	375±
Diameter of base of horn-core fore and aft	115
Diameter of base of horn-core vertically	105
Circumference of base of horn-core	335
Distance between tips of horn-cores (estimated)	840±

In the Pleistocene deposits of Alaska there have been found a number of specimens of this species whose horn-sheaths have been preserved. The substance which composes these horn-sheaths is subject to only slow decay and may, even in the climate of our northern States, when protected from weathering influences, resist destruction for ages. In the cabinet of Syracuse University there is the skull of a bison which was dug up about 1890 or previously, at a depth of 10 feet in a black muck, and which must have lain there many years. On the horn-cores of this skull there remain yet the horn-sheaths in a good state of preservation. The animal belonged to the existing species.

If in our climate the horns may endure so long, it is not astonishing that they should have been preserved since even early Pleistocene times in soils that have remained probably continuously frozen.

One of these specimens on which the horns yet remain has been illustrated by L. S. Quackenbush on plate 17, figs. 1, 2, numeral 2, of the paper which has already been quoted. This figure is here reproduced (pl. 10, fig. 3, *c*). The skull referred to is the one on the right side. It was found at the same locality as the skull above described and figured (pl. 10, figs. 1, 2, 3, *a*). The specimen which retains the horns probably remains at Fox Gulch, which place is not far from Dawson, Yukon Territory. No description of it has been published. The figure shows well the size and form of the horns. Were the sheaths removed the cores would probably have approximately the length and curvature of the specimen shown on the left side of figure 3.

Figure 1 of plate 13 represents another partial skull retaining the horns, which was seen by C. W. Gilmore, in a laundry, in Dawson, Yukon. No measurements were taken.

In the United States National Museum there is still another skull which it appears to be necessary to refer to *B. occidentalis*. This has

the catalogue number 5513, and was found 12 miles above the mouth of Pelly River, Yukon Territory. The finder was Charles Sheldon, who in 1905 presented the skull to the United States National Museum, through W. H. Osgood. It lacks the lower jaws, the maxillæ, premaxillæ, and the nasals. It is remarkable on account of the shortness of the horn-cores. The following measurements have been taken:

Measurements of No. 5513, United States National Museum.

	mm.
Distance from lower lip of foramen magnum to fronto-nasal suture	270
Width at mastoid region	290
Width at hinder ends of temporal fossæ	194
Width at constriction between orbits and horn-cores	288
Width at rear of orbits	355
Height of occipital crest above lower lip of foramen magnum	150
Width between bases of horn-cores	290
Diameter of base of horn-cores, fore and aft	102
Diameter of base of horn-cores, vertical	93
Length of horn-core on upper curve	220
Length of horn-core on lower curve	295
Circumference of horn-core at base	280
Distance between tips of horn-cores	650
Distance from occipital protuberance to middle of line joining rear of orbits	215
Distance between base of horn-core at the tip	208

It will be seen that the dimensions of the horn-cores are greatly like those of *B. bison*. In this respect the specimen resembles that figured by Allen on plate 4 of his work already cited. Both these skulls differ, however, from those of *B. bison* in having the bases of the horn-cores pass outward from the skull without drooping, as they do probably always in the species last mentioned. Such skulls might be looked upon as illustrating the transition from *B. occidentalis* to the existing American buffalo.

A few words may be said regarding the specimen, consisting of the horn-cores and the rear of the skull, more or less damaged, but appearing in front to come forward to the notch for the nasals, which was described by Sir John Richardson [1] as doubtfully *Bison priscus*. Lucas [2] regarded this skull as specifically identical with the type of *B. crassicornis*. There is in the United States National Museum a cast of this skull and there is here presented (pl. 13, figs. 2, 3) figures showing it from above and from the rear. It will be seen that the horn-cores are not as long as in other specimens of *B. crassicornis*, and that they do not sag as much. The measurements show that the individual must have had nearly or wholly the adult size. It appears more probable that the skull is that of *B. occidentalis*. The horn-cores are less curved than is most specimens of this species, but its index of curvature is not the lowest one (p. 178).

[1] Zool. Voyage Herald, p. 34, pl. 7, fig. 1. [2] Proc. U. S. Nat. Mus., vol. 21, p. 761.

Richardson has recorded various measurements some of which are here given, reduced to millimeters. These do not always agree exactly with those obtained by the writer from the cast.

Measurements of skull found at Kotzebue Sound.

Dimensions taken.	Richardson.	Hay.
	mm.	*mm.*
From middle of occipital crest to rear of nasals		235
From lower border of foramen magnum to rear of nasals, basinasal length		255
Height of occipital crest from lower border of foramen magnum	157	145
Height of occipital crest from upper border of foramen magnum		110
Width between bases of horn-cores	305	305
Width between hinder ends of temporal fossæ		185
Width at constriction between orbits and bases of horn-cores		273
Diameter of base of horn-core, fore-and-aft	94	97
Diameter of base of horn-core, vertical	76	83
Circumference of base of horn-cores		290
Length of horn-core on upper curve		300
Length of horn-core on lower curve		355
Distance between tips of horn-cores, in straight line	762	800
Tip of horn-core to upper border of base		280

Hilzheimer, in his paper of 1909, described as a new species *Bison primitivus*, based on a part of a skull with complete horn-cores, which had been discovered on the Lena River. In his table of measurements this is called *B. sibiricus*, an error corrected by the author in his second paper. This skull furnished Hilzheimer the following measurements: Width at the ear-openings, 290 mm.; width at constriction between horns and orbits, 310; width at rear of orbits, 370; circumference of base of horn-core, 370; length of horn-core along lower curve, 465; distance from base of horn-core to tip, 340; distance between tips of horn-cores, 910. If now a comparison be made of these measurements with those of *Bison occidentalis*, on page 168, it will be seen that the skull measurements of *B. primitivus* differ not essentially. The length of the horn-cores is not as great as that of No. 13721 of the American Museum of Natural History. The index of horn-curvature, as this index is determined by Tscherski, as explained below, is 136.7, which falls within the curvature of *B. occidentalis* (p. 178). The ratio of the circumference of the base to the length of the horn-core is 79.5, which is likewise within the limits of *B. occidentalis*. The curvature and direction of the horn-cores suggest strongly some specimens of *B. occidentalis*, and it seems possible that *B. primitivus* represents a specimen of the latter with unusually long horns.

A comparison of Pallas's figure (here reproduced, pl. 8, fig. 3) of the skull described by him, as cited on page 161, with those of *B. occidentalis* suggests that possibly that skull belonged to the species just named. Tscherski[1] has compared this skull with those of several other Siberian bisons and has given various indices. In many re-

[1] Mém. Acad. Imp. Sci. St. Petersb., ser. 7, vol. 40, 1893, pp. 78–84.

spects it stands apart from all those with which it was compared. The horn-sheaths and horn-cores are shorter and more strongly curved. The index of curvature of the horn-sheaths is given as 275.5; that of the horn-cores, as 130.8. The latter index is not so small as in some specimens of *B. occidentalis*, as may be seen below. As shown by the second figure given by Pallas the horns of his specimen sag somewhat strongly as they pass outward, but this may be an individual variation.

We may indicate the curvature of the horn-cores of bisons as Tscherski has done in the case of the horn-sheaths and horn-cores. The shortest distance between the tip of the horn-core and the base, taken of course on the upper side, is made 100. The ratio of this to the length along the lower curve is then determined. In the case of the type of the species, No. 4157, U.S.N.M., this is 150; in the case of No. 5514, U.S.N.M., it is 140; in No. 2643, U.S.N.M., 142; in the American Museum specimen, it is about 122, according to estimates made from the photograph. Estimated from the figure published by Dr. J. A. Allen [1] a specimen from St. Michael, Alaska, presents an index of 125. The skull figured by Richardson and described here on page 176 has an index of 127. Here we have a pretty wide variation, a range probably as great as that found in horn-cores of specimens of *Bison bison*.

Reference has been made on page 162 to La Baume's paper on which he gives measurements of a number of skulls supposed to belong to *Bison priscus*. As bearing on the question of the relationship of *Bison occidentalis* to *B. priscus* the following statements may be made. We leave out of consideration La Baume's specimen from Marienburg, as being imperfect and probably not cospecific with the others. The shortest horn-core of five measured by La Baume measured 390 mm. along the upper curve and 470 mm. along the lower. The longest horn-core of the six specimens referred in the present paper to *B. occidentalis* measures 355 mm. along the upper curve, 420 mm. along the lower. With this shorter length there goes a stouter form. In the five skulls of La Baume's list in which may be determined the ratio of the length of the horn-cores along the lower curve, made equal to 100, to the circumference at the base, the ratios, or indices, vary from 57.5 to 71. In the six specimens of *B. occidentalis* here recorded, the ratios vary from 76 to 86. In the two specimens of *B. priscus* on which the measurement could be made, the distance from tip to tip of the horn-cores was respectively 1,010 and 1,050. In *B. occidentalis* the measurement varies from 700 mm. to 920 mm. It is evident therefore that the forms included under *B. priscus* have longer and slenderer horn-cores than do the individuals of *B. occidentalis*.

[1] American Bisons, pl. 4.

BISON CRASSICORNIS Richardson.

In his paper on The Fossil Bisons of North America, Lucas presented illustrations of three partial skulls of this species, all of which had been brought from Alaska. Since the publication of that paper a number of other specimens have come to light; and it is proposed to illustrate here some of these. Unfortunately up to this time, so far as the writer knows, nothing like a complete skull of the species has been discovered, or at least made known.

A fine specimen showing the rear of the skull and the horn-cores complete, except a very little at the extreme tip, is in the United States National Museum and has the catalogue number 5726. Mr. Gilmore in his paper previously referred to, on plate 10, published a figure showing a rear view of the skull. This figure is here reproduced, and another is furnished which gives a view from above (pl. 14, figs. 1, 2); that is with the face directed toward the observer.

The following measurements have been taken, as shown in the first column. Measurements of other skulls are presented in the second, third, and fourth columns. In the fifth column are measurements of a skull of a bison found in the basin of the Jana River, in Siberia, and described further on page 181.

Measurements of skulls.

Dimensions taken.	No. 5726 U.S.N.M.	No. 1584, U.S.N.M.	No. 5727, U.S.N.M.	No. 6834, Field Mus.	*"B. priscus,"* Jana River.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*
Length from middle of occipital crest to rear of nasals	280	.....	.....	337±	318
Distance from upper lip of foramen magnum to middle of occipital crest	111	110	105	.....	.....
Distance between bases of horn-cores	345	366±	362	380	328
Width of skull at auditory openings	284	290±	290	330	318
Width of skull at hinder end of temporal fossæ	200	180±	183	187	206
Width of skull between bases of horn-cores and orbits	282	350±	315	360	321
Width of skull at rear of orbits	352	350±	.....	400	379
Diameter of base of horn-cores, fore-and-aft	122	133	127	130	139
Diameter of base of horn-cores, vertical	120	103	111	97	134
Circumference of horn-cores at base	367	343	380	350	461
Length of horn-cores on upper curve	450±	455±	505±	490	557
Length of horn-cores on lower curve	535±	500±	570±	530	630±
Distance between tips of horn-cores	1,200±	1,120	1,270±	1,140	1,450±
Distance from middle of occipital crest to middle of line joining the rear of the orbits	230	.....	.....	.....	.....

In No. 5726 the distance from the front of the foramen magnum to the suture between the frontal and the nasals, the basinasal distance, is 266 mm. It has not been obtained in the other specimens.

A view of the illustrations given here shows that this species had horns considerably longer than those of any of the species already described in this paper. The horn-cores are directed, at the base outward, slightly backward and downward, then they rise only slightly. Beyond the bases they sag so much that the lower borders are on a level with the foramen magnum; and they rise at the tips

not much above the level of the forehead. If, after the manner of Tscherski, we make the distance from the base of the horn-core to its tip equal to 100, the length along the lower curve will be found equal to 125, in both No. 5726 and No. 1584, U.S.N.M. This index is to be compared with that of the other species; but the actual length of the horn-core is likewise to be taken into consideration.

The specimen of *B. crassicornis* which was figured by Lucas (pl. 74), No. 1584, United States National Museum, was found, according to the record, by J. Henry Turner somewhere on either the Yukon River or the Kotlo River (Birch Creek), Alaska. It presents only the left side of the rear of the skull and the left horn-core, the tip of the latter being broken off. In the second column, on page 179, is found such measurements as can be obtained. Those with the sign ± are estimated, but are not far from the correct figures. The diameters of the horns are not those given by Lucas, as that writer has apparently erred, an unusual thing in his case. The horn-cores of this specimen are flattened on the upper face much more than in the other specimens.

No. 5727 of the United States National Museum was found on Little Minook Creek, about 6 miles southeast from Rampart, Alaska. It was presented by Messrs. Bowen and Coole, miners on claim 21, through C. W. Gilmore. It was found at a depth of 21 feet from the surface, lying in the gravel, which itself lies on the bedrock. The gravel is overlain by what is there called muck. This, like the other specimens hitherto secured, presents only the rear of the skull, not reaching the orbits, together with the horn-cores. These last, however, lack a few inches at the tip. The measurements appear in the third column on page 179.

In the Field Museum of Natural History there is a pair of fine horn-cores joined to the rear of the skull (pl. 14, figs. 3, 4). The forehead extends anteriorly to the fronto-nasal suture. The specimen has the number 6834 and is labeled as having been secured at Point Barrow, Alaska. It is one of three bison skulls which were formerly in the University of Pennsylvania. The writer was kindly permitted to take notes and photographs of the specimen. The measurements appear in the fourth column on page 179. It will be observed that in most of the measurements this skull is the largest on the list. In the case of the distance between the hinder ends of the temporal fossæ this is short. This dimension seems, however, to be extremely variable. It will be noted that the horn-cores are more flattened at their base than any other specimen measured, although but little more than in No. 1584 of the United States National Museum.

Figure 5 of plate 14 represents a view of a partial skull which is in the Memorial Museum, at Golden Gate Park, San Francisco. It was

obtained at "26 claims below Carmack's," a few miles southeast of Dawson, Yukon Territory. The great value of this specimen lies in the fact that the horn-sheaths are yet preserved. The photograph from which the figure was engraved was kindly sent to the writer by W. G. Blunt, of the Memorial Museum. This gentleman informs me that the distance between the horns is 14 inches (350 mm.); the circumference of the horns at the base, 16½ inches (414 mm.); the extent from tip to tip, 5 feet 5½ inches (1,665 mm.).

This species, with its long, heavy, sagging horns, appears to be very distinct from any other mentioned in this paper. That the skulls here figured belong to the same species as those recorded under *B. antiquus* and *B. occidentalis*, the writer does not for a moment concede.

It seems to the author that F. A. Lucas was right when he identified Richardson's type of *B. crassicornis* with No. 1584 of the United States Museum and concluded that it was a species distinct from Leidy's *B. antiquus*.

Tscherski described[1] under the name *Bison priscus* various remains which had been discovered, some in the basin of the Jana River, some on Liakhof Island, some at the delta of the Lena. He figured one skull which had been found in the basin of the Jana River and which lacked some of the bones of the muzzle, but which still retained the horn-sheaths. Tscherski's figures are here reproduced (pl. 15, figs. 1, 2) on a somewhat smaller scale than the originals. A comparison of these illustrations with those here presented of Alaskan specimens seems to make it highly probable that the Siberian skull belonged to *Bison crassicornis*. In the fifth column, on page 179, are measurements which are in part those given by Tscherski, in part are determined from his data or from the illustrations. It is evident that the animal was a larger one than either of the others whose measurements are here given except No. 6834 of the Field Museum of Natural History, Chicago; and the horn-cores are apparently longer than even in this. Nevertheless, the space between the horn-cores is less than in the others. The dimensions of the bases of the horn-cores are those given by Tscherski for the bases of the horn-sheaths, but there can be little difference. The length of the horn-cores on the upper border has been taken from the Russian author's statements, on his page 85; the lower curve is estimated from his figure and indices. According to Tscherski's computations the length of the horn-core is to that of the horn-sheath as 100 to 144.3. The author just named gives as the index of the curvature of the horn-sheath 178.9. This figure is obtained by measuring the chord, the shortest distance between the upper border of the base of the horn and its tip, regarding this as 100 and comparing it with the

[1] Mém. Acad. Imp. Sci. St. Petersb., ser. 7, vol. 40, pp. 75–152.

length of the horn on the outer curve. In like manner we may obtain the index of the curvature of the horn-core. As determined by Tscherski, this is 119.4; in No. 1584, U.S.N.M., the index is about 125; in No. 5726 it is 125, as has already been stated.

If the width of the forehead is regarded as 100 the length of the forehead from the occipital crest to the rear of the nasals will be in Tscherski's Jana skull 83.9, while in No. 5726 of the United States National Museum it will be 79.

BISON ALLENI Marsh.

The type of this species is a horn-core which was found in the Blue River near Manhattan, Kansas, and which is preserved in the collection of Yale University. The writer has studied the original specimen and has taken measurements from it. He has also made use of a cast of the specimen now in the United States National Museum in making comparisons with other specimens. The measurements of the original are given in the second column of the following table. The writer's own measurements differed but little from those made by Lucas. There is a partial skull of the same species in the collection of Stanford University, California; and this has been figured by Lucas in the paper already cited (pls. 79 and 80). Lucas's measurements appear below in the third column.

In his paper already referred to, Gilmore published (pl. 11) a figure of a pair of horns joined by the rear of the skull. This is No. 2383, United States National Museum, and was discovered on Little Minook Creek, a few miles southeast of Rampart, Alaska. It was afterwards used to adorn the roof of a miner's cabin, and thus attracted the attention of Gen. Timothy E. Wilcox, of the United State Army, who secured it for the United States National Museum. This specimen is of especial value because of the presence of the sheaths of the horns. These are somewhat decayed away at the base and somewhat weathered and splintered elsewhere; but the specimen is extremely valuable, and adds greatly to our knowledge of the species. The measurements appear in the fourth column. Gilmore's illustration is reproduced for comparison with other specimens (pl. 15, fig. 3). In the first column are given the measurements of another skull which will be here especially considered, No. 7706, United States National Museum.

Measurements of skulls of Bison alleni.

Dimensions taken.	No. 7706, U.S.N.M.	Type-specimen.	Specimen in Stanford University.	No. 2383, U.S.N.M.
	mm.	*mm.*	*mm.*	*mm.*
Length from rear of condyles to front of premaxillæ	606			
Length from front of foramen magnum to front of premaxillæ	560			
Length from occipital crest to front of premaxillæ	630			
Length from occipital crest to rear of nasals	287			
Length from occipital crest to front of nasals	512			
Length from occipital crest to line joining rear of orbits	232			224
Length from front of premaxillæ to line joining rear of orbits	404			
Length from front of foramen magnum to rear of hard palate	230			
Length from front of foramen magnum to line joining rear of hinder molars	240			
Length from lower border of foramen magnum to rear of nasals, basinasal length	295			
Height of occipital crest from lower border of foramen magnum	152			163
Height of occipital crest from upper border of foramen magnum	111			125
Greatest width at ear openings	282			
Width of foramen magnum	46			50
Width of rear of skull at occipitotemporal sutures	242			215
Width at hinder ends of temporal fossæ	190			157
Width between bases of horn-cores	310			295
Width between bases of horn-cores and orbits	286			271
Width at articulations of lower jaws	253			225
Width at rear of orbits	333			330
Width at front of orbits	268			
Width on maxillary ridge at maxillomalar suture	212			
Width from outside to outside of nasals, straight	103			
Diameter of orbit, fore-and-aft	78			
Diameter of orbit, vertical	75			
Level of palate below occipital condyles	7			
Height of skull from palate to rear of nasals	185			
Diameter of base of horn-cores, fore-and-aft	97	140	160	111
Diameter of base of horn-cores, vertical	93	115	130	106
Circumference of base of horn-cores	340	415	480	343
Length of horn-core on upper curve	430	620	635	
Length of horn-core on lower curve	505	770	710	
Length of horn on upper curve	600			720
Length of horn on lower curve	737			895
Extreme distance between outer border of the two horns	980			1,150
Distance between tips of horn sheaths	635			765
Distance between tips of horn cores	900		1,338	1,100±
Distance from upper border of base of horn core to tip	425			465

By far the most complete skull of a fossil bison yet found in North America is one which is here identified as *B. alleni* and which was discovered during mining operations on Hunter Creek just below the mouth of Dawson Creek and about 6 miles southeast of Rampart, Alaska. It was found on the top of gravel beneath 20 feet of silt. James Nelson, the finder, appreciating the scientific value of such a rare specimen, carefully exhumed it and shipped it to Henry M. Eakin, of the United States Geological Survey. From him it was purchased by the writer, and it is now deposited in the United States National Museum under the number 7706. The specimen consists of the skull nearly complete, including the lower jaws and five cervical vertebræ (pls. 16, 17). From the skull are missing most of the right malar bone, a part of the right zygomatic process of the squamosal, the ethmoid bones and vomer, the left coronoid process of the lower jaw, all the upper premolar teeth, the lower incisors and

the anterior two right lower premolars. The horn-sheaths are represented by the distal half or more of each, but the basal portion had decayed before exhumation. The bone is in a fine state of preservation, apparently mineralized, and not adhering when the tongue is applied to it. The surface is irregularly stained and mottled with light and dark brown. The lachrymals and the edges of the adjoining bones, the anterior faces of the pedicels of the horn-cores and some streaks across the forehead are of a light buff color. While the animal was mature, it was not aged. The suture between the frontal bones is still open to within about 40 mm. of the coronal suture; while the latter may be said to be just beginning to close. The teeth are well preserved and in fine condition for study. A comparison of the diameters of the horn-core and the length shows that the animal lacked considerable of being as large as either the type specimen or the one represented by the skull now

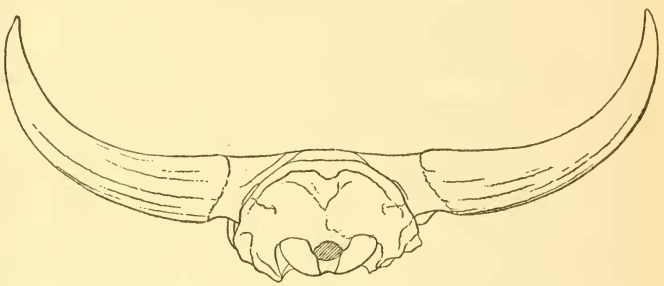

FIG. 7.—BISON ALLENI. SKULL IN UNITED STATES NATIONAL MUSEUM, No. 7706. VIEW FROM THE REAR.

in Stanford University, California.[1] That the specimen belonged to *B. alleni* seems evident from the rather long, slender, and uniformly curved horn-cores (fig. 7). They are much different from those of any of the species already mentioned in this paper. As will be seen from the illustrations, the horns are directed outward, upward, somewhat backward, and at length strongly inward. Toward the points they are thrown backward more than in No. 2383 of the United States National Museum. Such differences must be regarded as probably due to individual or sexual variation. On account of the weathering to which the skull was probably subjected before burial, the materials of the horn-sheaths is considerably loosened up and splintered. The color of this is mostly gray, but toward the tips the horns are much darker. These tips were originally probably nearly black for a distance of a hundred millimeters or more. On taking a full-face view of the skull (pl. 16, fig. 1) it will be seen that

[1] Lucas, Proc. U. S. Nat. Mus., vol. 21, p. 766, pls. 79 and 80.

it is narrower as compared with that of the American Museum specimen of *B. occidentalis* (pl. 10, fig. 1) and with that of the same museum's specimen here described as *Bison regius* (p. 192, pl. 18, fig. 1).

Seen in profile there is a prominence just in front of the occipital crest. The forehead is somewhat swollen behind the line joining the rear of the orbits. The nasals, where they join, are only slightly convex, fore and aft. Between the orbits the face is nearly flat. From the hinder edge of the hard palate to the fronto-nasal suture, in the midline, is 182 mm., close to one-third of the basilar length. The region occupying the front of the lachrymal and adjacent border of the maxilla is more depressed than in *Bison bison*. The lachrymal extends forward relatively farther than in *Bison bison*, its extremity being halfway between the anterior process of the frontal and the hinder end of the premaxilla. While being considerably longer than the same bone in *Bison bison* (138 mm. as compared with 110), the width is almost exactly the same (51 mm.). The ascending processes of the premaxillæ are more strongly concave on their upper border than in *B. bison*, and they approach nearer the nasals. The width of the foramen magnum, near its upper border, is 43 mm.; at the same place in *B. bison* the width is 50 mm. The vertical diameter is the same in the two specimens compared.

As might be expected, the lower jaw does not differ apparently from that of *B. bison*, except in its slightly greater size. From the incisive border to the angle it measures 457 mm.; from the lower border, just in front of the angle, to the summit of the articular surface, is 190; to the summit of the coronoid process, is 240. The height of the bone, at the rear of the last molar, is 78; at the front of the first true molar, 65; at the rear of the first premolar present ($pm._2$), 52; at the middle of the diastema, 43. At the last point named the bone is 20 thick, slightly less than in the specimen of *B. bison* at hand.

On a comparison of the complete skull here described with the rear of the skull with the horns, No. 2383, U.S.N.M. (pl. 15, fig. 3), it is seen at once that the horns of the latter were larger at the base and considerably longer. If, in each case, we divide the distance of the tip from the base, taken in a straight line, into the length along the lower curve and multiply this by 100, we obtain, in No. 2383, the index about 130; in No. 7706, the index 128.2.

While there is this greater size of horns in No. 2383, the skull in nearly all of its measurements is smaller, being greater only in the height of the occipital crest and in the size of the foramen magnum. Inasmuch as the sheaths of the horns of No. 2383 can not be detached, the length of the horn-cores has been determined only approximately. Figure 7 presents a view of the horn-cores of No. 7706, as seen from behind.

The upper premolars of No. 7706 are missing, but the molars (fig. 8) are present and in excellent condition. The lower incisors are gone, as well as the anterior two premolars of the right side. The other premolars and molars are present (fig. 9). The following measurements have been taken, as shown in the first column of the table. In the second column are given the measurements of the teeth of the existing American bison. The upper molars are those of No. 22374, U.S.N.M, in which the premolars are missing, as they are in the fossil. The measurements of the lower teeth are from No. 38302, U.S.N.M. Both of these specimens were of approximately the same

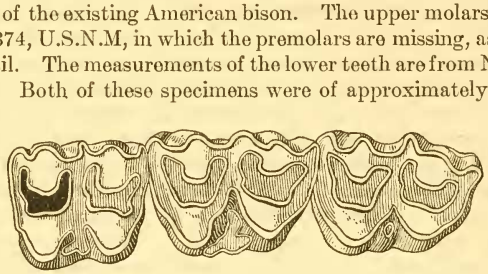

FIG. 8.—BISON ALLENI. LEFT UPPER MOLARS OF NO. 7706, UNITED STATES NATIONAL MUSEUM. $M.^3$ AT RIGHT. × ⅔.

age as was the specimen of *B. alleni*. It must be understood that the length of the tooth as here given is that of the grinding surface from front to rear, and that this diminishes as the tooth is worn. The width is taken at the base of the crown, and this width is indicated by the outermost line in the illustrations. The double lines indicate the arrangement of the enamel on the worn surface of the tooth. As the tooth is worn down the bands of enamel, other than those surrounding the lakes, approach nearer and nearer the narrow outer lines.

Measurements of teeth.

Teeth measured.	*B. alleni.*	*B. bison.*
	mm.	*mm.*
Length of the upper premolar-molar series	170±	148
Length of the upper premolar series (estimated from the sockets)	72±	62±
Length of the upper molar series	104	93
$M.^1$, length	30	26
width	27	27
$M.^2$, length	37	34
width	28	28.5
$M.^3$, length	37	34.5
width	27	28
Length of the lower premolar-molar series	175	152
Length of the lower premolar series	60	55
Length of the lower molar series	113	97
$Pm._2$, length	15	13
width	9	9
$Pm._3$, length	22	19
width	12	11
$Pm._4$, length	25	22
width	15	13.5
$M._1$, length	30	25
width	20	16
$M._2$, length	35	32
width	21	18
$M._3$, length	48	41.5
width	21	16

A comparison of the teeth of *B. alleni*, as represented in the skull here described, shows that they do not differ in structure essentially from those of *Bison bison*. They are, however, considerably larger than those of most specimens of the latter, but the hinder lower molar is hardly larger than that of No. 172689, U.S.N.M., from northern Alberta.

Figure 8 represents the true molars of the left side of the upper jaw. In m.[1] the internal column between the two lobes had been worn down to where it joined the enamel surrounding the crown; in m.[2] this point had not yet been reached; in m.[3] the summit of the column had just begun to wear. The enamel surrounding the cement lakes has a very simple structure and this will enable us to distinguish these teeth usually from those of *B. regius*, the next species to be described. So far as the writer can now judge, the teeth of *B. alleni* may usually be distinguished from those of *B. bison* by their greater size. Figure 9 gives a view of the lower teeth of the left side.

FIG. 9.—BISON ALENI. LEFT LOWER PREMOLARS AND MOLARS OF NO. 7706, UNITED STATES NATIONAL MUSEUM. ×⅔.

It may be profitable to determine certain indices for the purpose of showing the proportions of the skulls of bisons, as Osborn has proposed[1] for the horses. To obtain the cephalic index, the width at the rear of the orbits, multiplied by 100, is divided by the basilar length. The facio-cephalic index is obtained by dividing the distance from the front of the premaxillæ to the middle of a line joining the rear of the orbits, multiplied by 100, by the basilar length. The cranio-cephalic index is determined by dividing the cranial length[2] (distance from the middle of the occipital crest to the middle of the straight line joining the rear of the orbits, multiplied by 100) by the basilar length. In the case of the skull of No. 7706, here described the following results are secured: Cephalic index, 59.4; facio-cephalic index, 72.1; cranio-cephalic index, 41.4.

The atlas.—This bone (pl. 17, fig. 2) is wholly uninjured, except that a little of it has been broken off at the right hinder angle and a very little from the hinder border of the left hinder angle. Among the atlases described by Richardson, by Tscherski, by Dr. J. A. Allen, and Mr. A. Stewart are some which have practically the same size as that of the Alaskan bison here described; but the proportions are in some cases different.

[1] Mem. Amer. Mus. Nat. Hist., n. s., vol. 1, p. 57.

[2] In order to determine easily the cranial length it is necessary only to find mechanically the perpendicular of a right-angled triangle whose base is one-half of the distance between the rear of the orbits and whose hypothenuse is the distance from the occipital protuberance to the rear of an orbit. Similarly may be determined the facial length.

Measurements of skulls.

Dimensions taken.	No. 7706, U.S.N.M.	"*B. priscus*" from Jana River.	*B. latifrons* (?), Darien, Ga.	*B. occidentalis*, Kansas University.
	mm.	*mm.*	*mm.*	*mm.*
Length of centrum on the median line below	56	61	59	60
Length of neural arch in median line	66	64	.....	.....
Width of anterior articular surface	135	142	133	139
Height of anterior articular surface in median plane	58	.....	70	68
Width of notch in front of centrum	66	.....	.....	.....
Width of hinder articular surface	138	144	136	128
Width of bone on line through hinder borders of the arterial foramina	235	224	.....	.....
Greatest width of atlas	240	.....	240	232
Height of bone when placed on its hinder angles	138	.....	.....	.....
Greatest height of hinder end	107	.....	100	99
Distance from lower surface of hypophysis to top of arch	118	.....	.....	.....
Lateral diameter of spinal canal, front	50	.....	.....	.....
Lateral diameter of spinal canal, behind	65	59	.....	.....
Vertical diameter of spinal canal, behind	60	56	.....	.....

On comparing the atlas of No. 7706 with that of a specimen of *B. bison* certain differences are found, but it will require further comparisons in order to determine whether these differences are constant. When in the two atlases the distance from the outer end of the anterior articular surface to the outer end of the hinder articular surface is taken, it is found that in *B. bison* this is 48 per cent of the greatest width of the bone, while in *B. alleni* it is only 43 per cent. The notch in front of the neural arch is deeper than in the case of *B. bison*. The notch in front of the centrum is relatively and absolutely narrower in the fossil than in the living species. The inner borders of the foramina seen on the lower surface of the atlas have exactly the same distance between them in the atlas (greatest width 210 mm.) of the living bison as in the much wider atlas of *B. alleni*. In the latter, therefore, these foramina are much farther removed from the outer borders of the bone. In the American bison there is a much broader bar of bone running from the outer hinder angle of the wing to the hypophysis than in *B. alleni*. The atlas figured by Allen[1] seems in the latter respect to resemble more closely *B. bison*.

The axis.—This bone is completely preserved. The following are some of the dimensions. In the second column are the corresponding measurements from a mounted bison in the United States National Museum.

Measurements of axis.

Dimensions taken.	*B. alleni.*	*B. bison.*
	mm.	*mm.*
Length from front of odontoid process to lower border of hinder articular surface	138	140
Length from lower border of anterior articular surface to lower border of hinder articular surface	112	115
Width of anterior articular surface	133	127
Height of roof of spinal canal from lower border of anterior articular surface	90	80
Greatest height of bone near the hinder end	186	175
From outside to outside of lateral processes	160	140
From outside to outside of rear of pedicles	50	50
Greatest length of neural spine, fore and aft	108	112

[1] The American bisons, pl. 2, figs. 1–4.

From the above comparative measurements it will be seen that in some of its dimensions the axis of *B. bison* is larger than that of *B. alleni*. At the same time the atlas of the same individual of *B. bison* has a width of only about 220 mm. A peculiar feature of this axis of *B. alleni* is that the foramina for the vertebral arteries are wanting. In the next vertebra behind, the canal on the left side has its normal size, while that on the right side is greatly reduced in size. Beyond the differences in proportions indicated in the measurements there are few distinguishing features which appear likely to be constant. It is noted that the centrum at the constriction in front of the transverse processes is relatively wider in *B. alleni* than in *B. bison*.

The third, fourth, and fifth cervicals.—These are present and in almost perfect condition. The extremities of the neural spines of the fourth and fifth are broken off. The following measurements are furnished:

Measurements of cervicals.

Dimensions taken.	Vertebra.		
	3	4	5
	mm.	*mm.*	*mm.*
Length of centrum on floor of spinal canal	72	69	64
Width of anterior articular ball	44	45	42
Height of anterior articular ball	63	63	63
Width of hinder articular cup	56	55	55
Height of hinder articular cup	66	65	65
Distance from hypopophysis to top of neural spine	182	185±	192±
Width across anterior zygapophyses	103	108	114
Width across posterior zygapophyses	98	104	112
From outside to outside of transverse processes	175	173	163
From outside to outside of anterior extremities of inferior transverse processes	80	120	144

In the United States National Museum are two horn-cores (Cat. No. 5318), the right and the left, which the writer identifies as those of *B. alleni*. These were collected in 1905, near Minidoka, Idaho, about 50 miles nearly east of Shoshone, by F. C. Horn, engineer in the United States Reclamation Service. They were reported by G. K. Gilbert to have been found beneath a flow of basalt. From the same collector and from the same locality there were sent some bones belonging to a large elephant, probably *Elephas columbi*, possibly *E. imperator*, a part of a lower jaw of an extinct horse, and some jaws and teeth and some other bones of what appears to have been *Camelops kansanus*. All of these bones give evidences of having been buried in a bed of gravel and sand, which adhere closely to them.

This discovery is an important one, inasmuch as it adds another to the very few instances in which undoubted remains of any bison have been found in this country associated with those of the camel, thus apparently establishing the presence of one or more species at

the time when the Equus beds were deposited. In 1913 L. H. Miller [1] announced the discovery of remains of Bison, Equus, and a camelid in the upper San Pedro Pleistocene, at San Pedro, California. Recently J. W. Gidley [2] reported that a phalange of a camel had been found associated with bones and teeth of *Elephas primigenius*, Equus, and Bison, on the Old Crow River, Yukon Territory. It is the understanding of the present writer that these bones and teeth were found in recent deposits along the river and at different points. While it is probable that they had been washed out of deposits of the same age it is not certain that they were. In 1871 E. D. Cope reported bones of Bos or Bison from Port Kennedy Cave, not far from Philadelphia. From the same cave there was later described the genus *Teleopternus*, which was supposed by Cope to belong among the camels, but about which there exist doubts.

The horn-cores here referred to are much damaged and present the appearance of having been broken from the skull by human hands; but of the skull no part is present. One horn-core seems to extend to the base, but this is not wholly certain. One presents 460 mm. of the distal end in an uninjured condition; the other presents about the same length, with only a little of the tip missing. Apparently the length of the better horn-core along the upper surface was 660 mm.; along the lower curve the length was not far from 750 mm. Owing to the parts missing at the base, it is not possible to determine the diameters at that point. At a distance of 500 mm. from the tip of the horn-core the fore-and-aft diameter is 120 mm.; the vertical diameter, 82. In the type the diameters at the same distance from the tip are, respectively, 130 mm. and 108 mm. It will be seen, therefore, that the cores of the Idaho specimen are slenderer and much more flattened. If we determine the index curvature as in other cases it is close to 125; in the type it is 136.5, the curvature here being greater. These indices agree closely with those of the specimens from Alaska.

The basal half of the cores is rather strongly and sharply ridged and grooved; the distal half has the ridges and grooves broader, but usually not so sharply defined. On the concave side of the distal half or more there is a deep channel which widens to the tip of the core. A similar groove is seen in the type and a less conspicuous one in the horn-cores of the Alaska skull.

These horn-cores are referred to *B. alleni* despite the much greater degree of flattening which they present. This flattening does not appear to be at at all due to any post-mortem distortion.

Hilzheimer [3] ventured to remove from *Bison priscus* a skull, well preserved and retaining the horn-sheaths, which had been found on

[1] Univ. California Pub. Geol., vol. 7, p. 115.
[2] Smiths. Misc. Coll., vol. 60, p. 1.
[3] Sitz-Ber. Ges. Naturf. Freunde, Berlin, 1910, p. 144, figs. 8, 9.

the Vilni River, a tributary of the Lena, and which is now in the Berlin Geological Institute. It has been studied by both La Baume and Hilzheimer, and from their papers have been obtained the measurements here employed. A glance at Hilzheimer's illustrations suggests at once the close resemblance of the skull to the one from Hunter Creek, Alaska, here described. It is evident, however, that the face, in front of the orbits, was much narrower than in the Alaska skull; but this is the same difference which has been mentioned on page 173, in the discussion of *B. occidentalis*. The Siberian skull may, therefore, have belonged to a bull, the Alaskan to a cow. The following measurements of the two specimens are presented for comparison, and with them are given the same measurements compared with the basinasal length taken as 100.

Measurements, actual and reduced.

Dimensions taken.	Vilni River skull.		Hunter Creek skull.		Differences between reduced measurements.		
	Actual.	Reduced.	Actual.	Reduced.	Vilni River and Hunter Creek.	*Bison europæus.*	*Bos primigenius.*
	mm.	*mm.*	*mm.*	*mm.*	*Per ct.*	*Per cent.*	*Per ct.*
Basinasal length	285	100	300	100	0.0	0.0	0.0
Distance from occipital crest to nasals	284	99	287	95.6	3.4	5.6	16.8
Width between bases of horn-cores	374	131	310	103.3	27.7	14.0	21.6
Width at rear of orbits	267	128.7	333	111	17.7	12.2	16.8
Width at ear-openings	295	105.3	282	94	11.3	8.3	21.0
Circumference of base of horn-cores	340	.....	340	.....	.....	.....	.....
Length of horn along lower curve	710	.....	757	.....	.....	.....	.....

A comparison of the reduced measurements, found in the second and fourth columns, shows that the Siberian skull is considerably broader than the Alaskan, especially between the bases of the horn-cores; but likewise at the ear-openings and at the rear of the orbits. In order that the meaning of these differences may be, at least partly explained, the figures in the last three columns are presented. In the first of these three columns is given the difference between each reduced measurement in the Siberian skull and the corresponding one of the Alaskan.

The figures in the next two columns are derived from Tables 3 and 5 of La Baume's paper. In his Table 3 are presented the reduced measurements of 8 skulls of *Bison europæus* Owen (*B. bonasus*); in his Table 5 the reduced measurements of 17 skulls of *Bos primigenius*. The figures in the next to the last column of the table shown above have been obtained by taking the difference between the greatest and the least of the measurements of each kind in *Bison europæus*; those of the last column similarly from the reduced measurements of *Bos primigenius*. It will be seen that as regards the distance between the

occipital crest and the nasals, the difference is less between the Siberian and Alaskan skulls than in the other two species. Of course additional specimens of the Siberian and Alaskan forms would probably increase the difference. In the case of the width of the skull between the horn-cores, this is greater between the Siberian and the Alaskan skulls here compared than it is among all the other skulls; but the range in *Bos primigenius* is nearly as great. The great difference between the Vilni River skull and that from Hunter Creek may be indicative of a difference of species; future investigation must settle this. The differences found in the cases of the widths at the rear of the orbits and at the ear openings are not so great, and hence not so important perhaps. The figures in the last two columns show how variable are the skulls of the Bovidæ. It is to be noted likewise that the range of variation among the skulls of the extinct *Bos primigenius* is much greater than in the case of the existing European bison.

In case it shall result that Hilzheimer's *Bison europæus lenensis* is specifically the same as *Bison alleni*, the former name must be regarded as a synonym of the latter, this having been established in 1877.

BISON LATIFRONS, Leidy.

This species is treated incidentally under the succeeding one.

BISON REGIUS, new species.

Diagnosis.—A species related to *B. latifrons*, but having the horn-cores relatively longer, slenderer, and more strongly curved. Teeth with the enamel of the "lakes" furnished with reentering folds.

In the American Museum of Natural History there is a fine skull of a fossil bison which bears both horn-cores. This skull the writer has been permitted to study and describe; and likewise he has been furnished with the photographs from which have been prepared the figures here shown (pl. 18, figs. 1, 2). These present admirably the form and proportions of the skull and the characters of the horn-cores.

This very interesting specimen was found in the vicinity of Hoxie, Sheridan County, Kansas, in 1902, by Frank Lee and Harley Henderson. It was sold by them to Charles H. Sternberg and transferred by him to the American Museum of Natural History. This accession to the Museum was reported by Dr. W. D. Matthew [1] under the name *Bison latifrons*. An account of the discovery is given by Mr. Sternberg in his The Life of a Fossil Hunter, page 267, and the skull is illustrated by a figure. From this source are learned the circumstances connected with the discovery of the skull. The Missouri Pacific Railway Co. had shortened a creek by making a cut across a bend in it, and in doing so had come within about 2 feet of the skull. During a

[1] Science, vol. 29, 1909, p. 198.

subsequent freshet the skull was exposed; and shortly afterwards it was secured by Messrs. Lee and Henderson. This specimen was buried at a depth of 35 feet from the surface of the ground, but no account is given regarding the character of the deposit containing it.

The catalogue number of the specimen is 14346. The lower jaws were not secured. The nasal bones are missing, as well as the palatal processes of the premaxillæ. The base of the skull is damaged somewhat. The three molars of the right side are present and give important evidence regarding the relationships of the animal. The writer was at first strongly inclined to regard this skull as having belonged to the female of *Bison latifrons;* especially through the examination of the figures of skulls of the existing North American bison which are shown in J. A. Allen's work.[1] It is there seen that the females of this species have, often at least, horn-cores slenderer and more strongly curved than those of the males. If the horn-cores of the two sexes of *B. latifrons* varied in the same way, the fine pair in Cincinnati might be regarded as those of a bull; while the skull here described might be looked on as that of a cow. However, certain characters found in the teeth have convinced the writer that it is much more probable that the Hoxie specimen represents a distinct species.

Our knowledge regarding the great thickness and wide expanse of the horn-cores of *B. latifrons* rests principally on the fine pair, connected by the intervening part of the skull, which were found many years ago in Adams County, Ohio, and which are now in the collection of the Cincinnati Society of Natural History. These have been described and figured in various publications, especially by Lucas and Allen. The figures of the latter[2] are here reproduced (pl. 19) on a considerably smaller scale and joined so as to show their relative positions. Measurements have been presented by the writers just named, but these measurements differ somewhat in the two tables, and they differ from those taken by the writer on the cast of the cores in the United States National Museum. The three sets of measurements are here given:

Measurements of horn-cores of Bison latifrons.

Dimensions taken.	Allen.	Lucas.	Hay.
	mm.	*mm.*	*mm.*
Distance between the bases of the horn-cores	407	.....	382
Length of horn-core along upper curve	813	784	845
Length of horn-core along lower curve	853	840	910
Diameter at base of horn-core, fore-and-aft	.....	166	167
Diameter at base of horn-core, vertical	.....	146	148
Circumference of horn-core at base	510	520	507
Distance between tips of horn-cores	.....	1,775	1,800

[1] The American Bisons, Living and Extinct, pls. 5–7.

[2] Idem, p. 7, pl. 1.

At my request, Prof. N. M. Fenneman, of the University of Cincinnati, has measured the longer horn-core and has found the length along the upper curve to be 828 mm.; along the lower curve, 880 mm. Apparently a slight damage at the base on the underside makes the starting point doubtful. Eight hundred and eighty millimeters may be regarded as correct. The writer finds that the distance from the upper part of the base of the horn-core to the tip, in a straight line, is 805 mm. This, divided into the length along the lower curve and multiplied by 100, gives as the index of curvature about 110. These measurements are to be compared with those of the skull here described as *Bison regius*.

Measurements of skull of type of Bison regius.

	mm.
Length of the skull from lower border of the foramen magnum to front of premaxillæ	580
Length of the skull from middle of occipital crest to front of premaxillæ	640
Length from middle of occipital crest to fronto-nasal suture	320±
Distance from middle of occipital crest to line joining rear of orbits	315
Distance from front of premaxillæ to line joining rear of orbits	425
Distance between bases of horn-cores	362
Width across rear of skull at ear openings	305
Height of occipital crest above lower lip of foramen magnum	165
Distance between hinder ends of temporal fossæ	200
Width of skull at rear of orbits	360
Width of skull at front of orbits	265
Width at constriction between horn-cores and orbits	342
Width in front of orbits on maxillo-malar suture	212
Width at middle of maxillo-premaxillary suture	125
Greatest distance, in a straight line, across nasals, as shown by space occupied by them	83
Diameter of orbit, fore-and-aft	72
Width across occipital condyles	140
Width of foramen magnum	50
Distance between the anterior premolars	110±
Distance between the hinder molars	135±
Length of horn-core on upper curve	910
Length of horn-core on lower curve	1,015
Diameter of base of horn-core, fore-and-aft	160
Diameter of base of horn-core, vertical	147
Circumference of base of horn-core	478
Distance between tips of horn-cores	1,725

When a ruler is laid along the hard palate and extended to the occipital condyles, it is found that the latter are about 58 mm. above the level of the palate. In this respect the specimen agrees with two skulls of the American bison at hand. In the specimen of *B. alleni* above described, from Hunter Creek, Alaska, the condyles fall slightly below the line of the palate.

The following measurements were taken on the teeth (fig. 10). The grinding surface of m.[1] stands at a height of about 22 mm. above the fork of the roots; the others at a height of nearly 40 mm. This shows that the teeth are only moderately worn. For comparison there are given in the second column the measurements of the same teeth of *Bison bison*, No. 22374, United States National Museum.

Measurements of teeth.

Teeth measured.	*B. regius.*	*B. bison.*
	mm.	*mm.*
Length of the molar series	111	93
$M.^1$, length	32	26
width	31	26.5
$M.^2$, length	39	33
width	32	28.5
$M.^3$, length	40	34
width	30	28

If comparisons are made between the measurements and illustrations derived from remains of *B. latifrons* found in Ohio and the

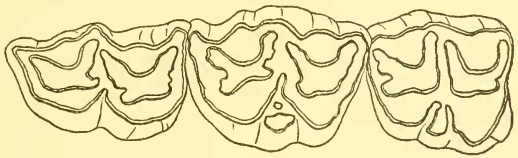

FIG. 10.—BISON REGIUS. RIGHT UPPER MOLARS OF TYPE. M^3 AT LEFT. $\times \frac{3}{4}$.

corresponding measurements and illustrations depicting the type of *B. regius*, it will be seen that *B. latifrons* has the forehead wider by from 20 to 45 mm.; that the horn-cores are of slightly greater diameter, but are somewhat shorter, and that they are far less strongly curved. The writer admits that it is possible that these differences may be due to individual, racial, or sexual variation. In the last-named case the Ohio animal might represent the male; the Kansas specimen the female.

Unfortunately, so far as the writer is aware, no teeth have been found with any horn-cores which belong with certainty to *B. latifrons*. Leidy [1] described and figured five large molar teeth of a bison, which, from their size, he regarded as belonging to *B. latifrons*. They had been found near Natchez, Mississippi, in association with mastodon, horse, bear, deer, megalonyx, mylodon, and a large extinct cat. The measurements of these teeth are given as follows:

[1] Smiths. Contr. Knowl., vol. 5, p. 9, pl. 2, figs. 2–7.

Measurements of teeth of Bison latifrons.

Teeth.	Length.	Width.
	mm.	*mm.*
M.1	37.5	27.4
M.2	37.5	27
M.3	43.5	35.4

According to Leidy's figures, however, the second upper molar has a fore-and-aft extent of 39 or 40 mm., and the hinder molar an extent of 41 mm. The width of this last-mentioned tooth is that at the bottom, where greatest. The width of the other two seems to have been taken at the middle of the height of the tooth. Furthermore, it is not certain that Leidy had the first true molar; hence that measurement had better be disregarded. Otherwise, the two sets of teeth are of practically the same size.

Leidy stated that "the crescentic enamel pits or islands of the grinding surface are more simple than in the ox, and appear relatively more capacious as a result of their greater simplicity or less degree of inversion of the sides of the pits." Figure 3 of his plate 2 shows well the size of the islands or lakes and the simplicity of the enamel of their walls. Leidy's figure, showing the grinding surface of the second upper premolar, is here reproduced (pl. 19, fig. 2). An examination of the lakes of *Bison regius* shows a different state of affairs. Here the lakes have the sides, especially the outer one of each, and to a less degree the inner one, pushed strongly toward the interior of the lake. The result is to produce in each lake a pair of narrow cornua projecting outwardly and a much contracted interior. There is another feature which is less commonly seen in bisons. In the front border of some of the lakes, or in the hinder border of others, or in both of these, there is seen a sharp infolding of the enamel, which considerably complicates its arrangement. The writer finds this complication in none of several recent specimens of *B. bison* examined. In the front wall of the posterior lake of the first upper molar of a set of teeth figured by J. A. Allen, found at Big Bone Lick, Kentucky, and referred to *B. bison*, we find an inflexion of the enamel, such as is found in *B. regius*. In examining several specimens of *Bubalus caffer*, the African buffalo, the writer finds in most of the lakes of the upper molars similar infoldings of the enamel. The character appears, therefore, to be of specific importance. It is possible that the large teeth described by Leidy do not belong to *B. latifrons;* but if not, there is probably indicated still another undescribed bison. It is, however, probable that they do belong there; and if so, *B. latifrons* and *B. regius*, among American bisons, stand at the extremes of the complication of the enamel in the walls of the cement lakes.

In 1846 W. M. Carpenter[1] described and illustrated with two woodcuts a fossil bison which had been found at San Felipe, on the Brazos River, Texas. The skull was preserved forward to the frontonasal suture (pl. 19, fig. 3). The horn-cores had lost their extremities, but there remained 2 feet of the right one, and 18 inches of the left. The width of the skull between the horns was 14 inches (357 mm.). The circumference of the horn-core at the base was 17 inches (434 mm.); at a distance of 18 inches from the base (probably in a straight line), 14½ inches (376 mm.). The width at the rear of the orbits was 14¾ inches (376 mm.); at the front of the orbits, 11½ inches (293 mm.). A comparison of these measurements with the corresponding ones of *B. regius* shows that the width between the horn-cores was almost the same; the width at the rear of the orbits 16 mm. greater in the Texas skull; at the front of the orbits 28 mm. greater in the Texas skull. This appears to show that the skull of the Kansas specimen narrowed more rapidly forward than that of the Texas bison. This might indicate that the Kansas specimen is the male, and the Texas specimen the female of the same species. Favorable to this view is the fact that the horn-cores of the Texas specimen are slenderer than those of the other skull. The bases of the horn-cores of the former are described as being nearly round. Calculations show that the diameter at the base was about 133 mm.; at a distance of 460 mm. from the base it was yet 117 mm. With the specimen described by Carpenter was a second upper molar; but it was so excessively worn that it affords no important characters. Its length near the roots was yet 40 mm.; the width, 30 mm.

It seems to be fitting, in closing this paper, that the principal characters by means of which the various species of North American bisons may be distinguished should be presented in a more succinct form than has been done on the preceding pages; and to this end the following table has been prepared:

Synopsis of the characters of North American bisons.

a^1. Species with the bases of the horn-cores directed at right angles with the longitudinal axis of the face.

b^1. Horn-cores, measured along the upper curve, equal to about three-fourths the distance between the bases of the cores, and about equal to the circumference of the base..... *antiquus.*

a^2. Species with the bases of the horn-cores directed obliquely to the longitudinal axis of the face and nearly toward the orbit of the opposite side.

b^2. Horn-cores short, stout, and curving outward, upward, and backward; length along the upper curve much less than the distance between the bases and not equaling the circumference of the base..... *bison.*

b^3. Horn-cores directed outward, upward, and somewhat backward; the length along the upper curve usually exceeding somewhat the distance between the bases and about equal to the circumference of the base..... *occidentalis.*

[1] Amer. Journ. Sci., vol. 1, p. 245, figs. 1, 2.

b^4. Horn-cores more elongated and directed considerably downward proximally; tips rising little above the face; the sheaths directed upward distally; the length of the cores exceeding the distance between the bases by from 24 to 70 per cent, and the circumference of the base by from 21 to 40 per cent; index of curvature about 125.. *crassicornis*.

b^5. Horn-cores not sagging at the base; directed outward, upward, and somewhat backward; exceeding the distance between the bases by about 40 per cent, and the circumference of the base by from 22 to 32 per cent; index of curvature about 130; tips of horn-sheaths directed strongly inward..... *alleni*.

b^6. Horn-cores long, heavy, and moderately curved; length along upper curve more than twice the distance between the bases and exceeding by more than 50 per cent the circumference at the base; index of curvature 110. Teeth with the enamel of the "lakes" very simple..... *latifrons*.

b^7. Horn-cores, as indicated by the type, longer, slenderer, and more curved than in *B. latifrons;* length along the upper curve two and a half times the distance between the bases and exceeding the circumference of the base by 90 per cent; index of curvature about 130. Teeth with the enamel of the "lakes" with reëntering folds..... *regius*.

EXPLANATION OF PLATES.

PLATE 8.

Skulls of Old World bisons known as Bison priscus.

Fig. 1.—Skull found near Pavia, Italy. After H. v. Meyer.
2.—Skull supposed to have been found in Hungary. After H. v. Meyer.
3.—Skull showing horns, found in Siberia. After P. S. Pallas.

PLATE 9.

Skulls of Bison priscus and B. occidentalis.

Fig. 1.—Dorsal view of skull in British Museum of Natural History and known as *Bison priscus*. From a cast.
2.—Rear view of same skull. From a cast.
3.—Dorsal view of skull of the type of *Bison occidentalis*, No. 4157, United States National Museum.
4.—Rear view of same skull.

PLATE 10.

Skulls of Bison occidentalis.

Fig. 1.—Dorsal view of skull found in Yukon Territory, No. 13721, American Museum of Natural History.
2.—Rear view of same skull.
3*a*.—Oblique view of same skull. After Quackenbush.
3*c*.—Dorsal view of skull showing horns, Yukon Territory. After Quackenbush.

PLATE 11.

Skulls of Bison occidentalis.

Fig. 1.—Dorsal view of Alaskan skull, No. 5514, United States National Museum.
2.—Rear view of same skull.
3.—Dorsal view of skull from Yukon Territory, No. 2643, United States National Museum.
4.—Rear view of same skull.

PLATE 12.

Skulls of Bison occidentalis.

Fig. 1.—Dorsal view of skull from Alaska, No. 6832, Field Museum of Natural History, Chicago.
2.—Rear view of same skull.
3.—Dorsal view of skull in American Museum of Natural History, New York. Exact locality unknown.
4.—Rear view of same skull.

PLATE 13.

Skulls of Bison occidentalis.

Fig. 1.—Dorsal view of skull in Dawson, Yukon Territory, shows the preservation of the horns.
2.—Dorsal view of skull found at Kotzebue Sound. From a cast in the United States National Museum. Original in British Museum of Natural History.
3.—Rear view of same skull. From a cast.

PLATE 14.

Skulls of Bison crassicornis.

Fig. 1.—Dorsal view of skull found in Alaska, No. 5726, United States National Museum. After Gilmore.
2.—Rear view of same skull.
3.—Dorsal view of skull found in Alaska, No. 6834, Field Museum of Natural History.
4.—Rear view of same skull.
5.—Rear view of skull found in Yukon Territory, now in Memorial Museum, San Francisco.

PLATE 15.

Skulls of Bison priscus? and B. alleni.

Fig. 1.—Dorsal view of skull of supposed *B. priscus*, found in Siberia and retaining the horns. After Tscherski.
2.—Rear view of same skull.
3.—Rear view of skull of *B. alleni*, found in Alaska, No. 2383, United States National Museum. After Gilmore.

PLATE 16.

Skull of Bison alleni.

Fig. 1.—Dorsal view of skull with horns, found in Alaska, No. 7706, United States National Museum.
2.—Rear view of same skull.

PLATE 17.

Skull and cervical vertebræ of Bison alleni.

Fig. 1.—Lateral view of same skull as that of plate 16.
2.—Ventral view of atlas found with same skull.

PLATE 18.

Skull of Bison regius.

Type. In American Museum of Natural History.

Fig. 1.—Dorsal view.
2.—Rear view.

PLATE 19.

Skull, horn-cores, and tooth referred to Bison latifrons.

Fig. 1.—Front view of skull and horn-cores of specimen in Cincinnati Society of Natural History.
2.—Tooth supposed to belong to *B. latifrons*. After Leidy.
3.—Dorsal view of skull and horn-cores referred by Blake to *B. latifrons*. After Blake.